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$MgSiO_3$ ペロブスカイトの反応帯成長速度
Growth kinetics of $MgSiO_3$ perovskite reaction rim up to 50 GPa

西 真之 [1*], 西原 遊 [1], 入舩 徹男 [1]
Masayuki Nishi[1*], Yu Nishihara[1], Tetsuo Irifune[1]

[1] 愛媛大学地球深部ダイナミクス研究センター
[1]Geodynamics Research Center, Ehime University

Mineral diffusion rates provide important constraints for understanding many physical and chemical processes in the Earths interior, including mantle rheology and chemical transportation. For many mantle silicates, Si is the slowest diffusion species and the rheology of the lower mantle is considered to be controlled by Si diffusion in perovskite. However, recent experimental studies have indicated that Mg lattice diffusion in perovskite is also extremely slow and has very similar diffusivity to Si. Although the characteristic lattice diffusivity of Mg in perovskite has been found, little is known about the rate of its grain boundary diffusion. Furthermore, there is no experimental data on the pressure dependence of diffusivity in perovskite. In this study, we examined the growth kinetics of the polycrystalline perovskite rim between periclase and stishovite under lower mantle conditions up to 50 GPa. Based on the experimental results, the grain boundary diffusivity in $MgSiO_3$ perovskite and the chemical transportation in the mantle are discussed.

We performed high-pressure and high-temperature experiments using a Kawai-type high-pressure apparatus (Orange 3000 and MADONNA II) installed at Ehime University, Japan. Single crystals of periclase and a fine powder of quartz were used as the starting materials for the reaction experiments. In order to determine the mobile component controlling the overall reaction progress, a small amount of Pt powder was placed onto the flat surface of the periclase. The sample assembly was composed of sintered (Mg,Co)O and ZrO_2 pressure mediums, a cylindrical $LaCrO_3$ heater, a molybdenum electrode, and a graphite sample capsule. Thicknesses of reaction layers and corresponding grain widths were measured by a Field-Emission Scanning Electron Microprobe (FE-SEM) (JEOL JSM-7000F) equipped with an Energy Dispersive Spectrometer (EDS) at Ehime University. Raman spectroscopy revealed that the reaction rim consisted of perovskite.

The Pt-markers were always observed at the perovskite-periclase interface in the run products. This indicates that the rim growth is controlled by the diffusion of Mg or O in perovskite and Si is the slowest diffusion species in this system. The growth rate of perovskite in this study is not parabolic but slower. Using the kinetics of coupled rim growth and grain coarsening, we calculated the grain boundary diffusion coefficient of Mg which possibly controls the rim growth. The grain boundary diffusion coefficient of Mg in the perovskite was determined to be ˜4-5 orders of magnitude faster than that of Si. We found that the bulk diffusivity of Mg in polycrystalline perovskite is affected by the grain boundary when we consider the possible grain sizes and temperatures in the lower mantle. Accordingly, grain boundary diffusion in perovskite may be an effective mechanism for chemical transportation of divalent cations in the lower mantle.

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